Rocky Mountains Southwest Great Plains

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Snowpack Accumulation Before and After Thinning a Dog-Hair Stand of Lodgepole Pine

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Snowpack water equivalents were measured 5 years before and 3 years after thinning a 90-year-old stand of lodgepole pine in southern Wyoming. Peak snowpack water equivalent was increased about 30%.

Keywords: Watershed management, forest thinning, snow hydrology, water yield improvement

Management Implications

Uniformly distributed thinning of a 90-year-old dog-hair lodgepole pine stand increased average snowpack water equivalent by 53 mm or about 30%. Based on height-growth curves for lodgepole pine and information from earlier snow studies in the area, the increased snowpack water equivalents in the thinned area are likely to persist for 30 years or longer without further harvesting. Peak snowpack water equivalents would be expected to increase again after future timber harvesting on the same area. Presumably, greater snow accumulation and water yield would be expected after thinning similar dog-hair stands, because of added effects of reduced transpiration losses, a greater-unit area concentraton of snowmelt water when transpiration rates are low, and perhaps greater year-to-year carryover of soil moisture.

Introduction

There are approximately 1.6 million ha of lodgepole pine (*Pinus contorta* Dougl. ex Loud) on commercial forest lands in Colorado and Wyoming. This timber type generally occurs above about 2,600 m in southern Wyoming and Colorado, and above about 2,000 m in northern Wyoming, occupying an important snow producing zone. Various studies of snow in the lodgepole pine type in Colorado, Wyoming, and Canada demonstrated that snow accumulation is greater in forest openings and in small clearcuts than under unbroken canopies of lodgepole pine (Niederhof and Dunford 1942, Wilm and Dunford 1948, Hoover and Leaf 1967, Golding and Swanson 1978, Gary 1980, Gary and Troendle 1982). Clearcutting in small blocks or patches about 5 tree heights (5H) in width, spaced at least 5H apart, and on sites protected from wind is the recommended silvicultural system for optimum redistribution of snow to improve water yield in lodgepole pine and spruce-fir forests (Leaf 1975, Troendle and Leaf 1980). However, the best combination of silvicultural and watershed management plans for the high density nearly stagnant, second-growth and other developing dense young stands that may or may not be clearcut has not been determined (Alexander 1974, Goodell 1964).

Study Area

The study area was an extensive lodgepole pine forest, on a gently rolling plateau, about 2,740 m above mean sea level, well exposed to prevailing southwest winds, and about 3.2 km southeast of Foxpark, in southern Wyoming. The area usually is snow-covered from late November to early May. Snowfall amounts are relatively small but account for 50–75% of the annual precipitation of 450 to 500 mm.

The lodgepole pine forest over the general area was regenerated after a large wildfire about 90 years ago. Since 1940, various areas within the forest have been periodically thinned to 1,000 to 2,000 stems/ha. In earlier studies in the same study area, a control area

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was established for another study that determined snow accumulation differences resulting from a small clear-cut patch that was progressively enlarged (Gary 1974, 1980). The control area was about 0.16 ha, with 49 permanent snow measuring points. Tree density in the control area was about 2,000 stems/ha (about 2.3 m between trees), diameter at breast height averaged about 137 mm, and tree height averaged about 10.7 m.

In a very dense stand (dog-hair), about 400 m northeast of the control area, a permanent snow course with 20 sample points was established in 1972. Snow sample points were spaced 15 m apart or more along a meandering 300-m-long transect. A similar snow course also was established on a twice-thinned stand starting about 100 m immediately east of the dog-hair plot (fig. 1). The dog-hair plot had an estimated 25,000 stems/ha, diameter breast height averaged about 56 mm, and height of dominant trees averaged about 9 m. The twice-thinned plot, adjacent to the dog-hair plot, had about 1,080 stems/ha, diameter breast height averaged 170 mm, and average height was about 13 m.

In the summer of 1981, the existing dog-hair stand was thinned to a density of about 2,100 trees/ha. The remaining trees were uniformly distributed over the whole study area. Average diameter of the residual trees was about 105 mm and average height was about 9 m (fig. 2). Basal area of the thinned dog-hair stand was about 16.07 m^2/ha.

Snow Measurements

Snow measurements were taken near the time of maximum snowpack, usually about mid-March, at the control plot, at the dog-hair plot, and at the twice-thinned plot. A federal-type snowtube was used to collect snow samples, which were weighed and converted to the nearest 2.5-mm water equivalent. The snow measurements were started in the spring of 1973 and were taken annually at the dog-hair and twice-thinned plots through the spring of 1977. From 1978 through the spring of 1981, no snow measurements were taken on the two plots. After the dog-hair plot was thinned in 1981, snow course measurements in the thinned dog-hair and twice-thinned plots were resumed in the spring of 1982, and continued in 1983 and 1984, at the same sample points as used previously. All snow sample points in the thinned dog-hair plot were more than 100 m from other thinned areas.

Figure 1.—Contrast between the twice-thinned and unthinned dog-hair plots.

Figure 2.—Dog-hair stand after commercial thinning to 2,100 trees/ha in 1981.

Results

The annual summary of snowpack water equivalents near the time of maximum snowpack for the three study plots is given in table 1. Over the 12-year period, as expected, there was considerable year-to-year variation among plots. In 1980, for example, the control area had four times more snowpack water equivalent than observed on the same plot in 1981. The snow water equivalent ratios of the thinned plots to the control plot provided general evidence of an increase in snow accumulation over the thinned dog-hair plot. The average snowpack water equivalent ratio of the control area to the dog-hair plot was 0.99 for the period 1973 through 1977; after thinning of the dog-hair plot, the average ratio from 1982 through 1984 was 0.76. In contrast, the average ratio of the twice-thinned plot to the control plot indicated a relatively constant difference during both the calibration period from 1973 through 1977 (0.87) and the period 1982 through 1984 (0.85).

Further evidence of the relative increase in snowpack water equivalents after thinning in the dog-hair plot is illustrated in figure 3. The double-mass plots were based on accumulated annual snowpack water equivalents at the dog-hair and twice-thinned plots with the concurrent accumulated values for the control plot. A decided change in snow accumulation was indicated by an abrupt change in the slope of the double-mass curve at the thinned dog-hair plot starting in 1982, the first winter season after thinning. The double-mass curve for the twice-thinned plot followed a consistent slope, indicating no apparent shift in the pattern of snow accumulation.

Table 1.—Snow water equivalents (in millimeters) near the time of maximum snowpack and accumulation relations between sites

Year	Control (A)	Twice-Thinned (B)	Dog-Hair (C)	Ratio	
				A/B	A/C
1973	196	228	199	0.86	0.98
1974	196	216	195	0.91	1.01
1975	189	221	191	0.86	0.99
1976	185	214	188	0.86	0.98
1977	79	96	84	0.82	0.94
1978	275	---	---	---	---
1979	250	---	---	---	---
1980	248	---	---	---	---
1981	56	---	---	---	---
1982	169	196	229	0.86	0.74
1983	137	174	193	0.79	0.71
1984	213	242	260	0.88	0.82

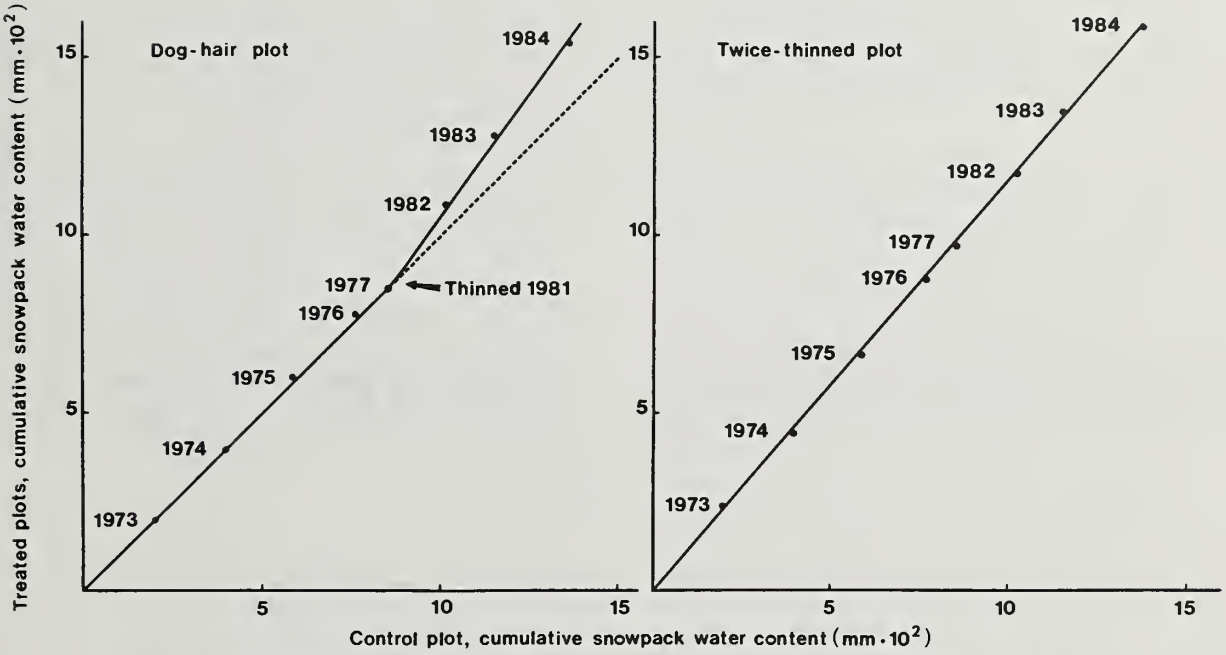

Figure 3.—Double-mass plotting of snowpack water equivalents for the thinned dog-hair and twice-thinned plots.

An analysis of covariance based on the available data shown in table 1 indicated a highly significant ($\rho < 0.001$) effect of thinning the dog-hair stand. The slope coefficients were not significantly different for the two study periods. The adjusted mean snowpack water equivalent for the dog-hair plot, after analysis of covariance, from 1973 to 1977, was 173 mm. The adjusted mean snowpack water equivalent after thinning was 226 mm for the period 1982 through 1984. The difference after thinning, about 53 mm, indicated an increase in snow accumulation of about 30 percent. Analysis of covariance using data from the twice-thinned plot indicated no significant difference between the 1973 to 1977 and 1982 to 1984 study periods, further substantiating a significant increase in snow catch resulting from thinning the dog-hair plot. The adjusted snowpack water equivalent for the first period was 199 mm, and 202 mm for the second period.

Conclusions

Based on other studies in Wyoming and Colorado (Gary 1979, Gary and Troendle 1982, Troendle and Meiman 1984), the greater annual snowpack water equivalents in this study apparently were the result of reduced snow interception by trees and vaporization losses from intercepted snow. The increased snowpack water equivalents resulting from thinning the dog-hair stand of lodgepole pine are likely to persist for many years without further thinning, based on an earlier local study (Gary 1979).

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